An Empirical Model of Long-Term Contracting with Manipulation *

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Abstract

Accounting frauds are corporate events in which management intentionally misleads investors by deviating from commonly-accepted accounting practices. To study its prevalence and real consequences, we develop an agency model based on DeMarzo and Sannikov (2006) in which managerial incentives and manipulation of reported earnings give rise to accounting frauds. We derive the optimal compensation contract under the possibility of misreporting and random SEC investigations. Preliminary estimates suggest that a small portion of net income is misstated but such misstatements cause a substantial reduction of firm value even in large public firms.

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A company's accounting numbers form the backbone of its contracting arrangements. Lesser known, however, is that accounting restatements are a relatively common occurrence, sometimes years after they have been issued. In a restatement, a firm will issue a correction, usually in a SEC form 8-K Item 4.02 Non-Reliance disclosures, providing information about up to five years of misstated information and adjust current period financial statements. To set ideas, based on data collected in Audit Analytics, about 1 out of 10 years in firms in the major three US exchanges was restated (Figure 1). Over the period 2000 to 2016, a grand total of \$1.4 trillion was restated - at a market P/E ratio around 15, this amounts to an implied market value at about the GDP of a small country.

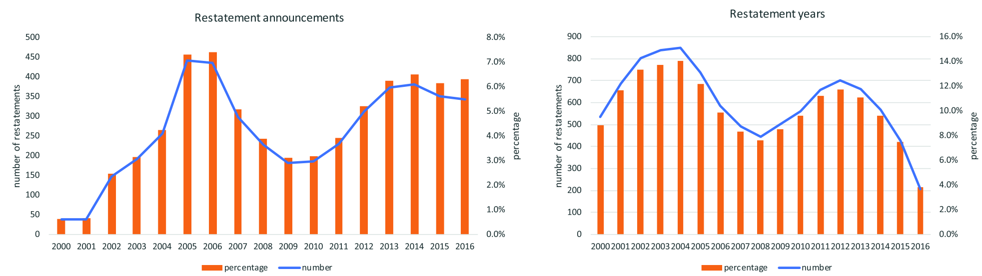

Figure 1: Evidence on accounting restatements

To our knowledge, the economic drivers of restatements and their consequence on efficiency are unknown. Our primary objective is to fill this gap by taking a first step at quantifying the economic costs of restatements. We ask three questions:

(1) In a long-term relationship between the firm and its management, what informational frictions drive restatements?

(2) How pervasive is accounting manipulation and what would unmanipulated accounting numbers look like?

(3) How much more efficient would accounting be for stewardship purposes without manipulation and what are the real operating costs to the firm of misstatements?

Answering these questions provides a framework to analyze restatements in a contracting setting, and separate the contracting costs of suitably compensating the manager and the real costs of the manager's value-destroying actions adding to a growing literature on estimating optimal contracts (Margiotta and Miller 2000; Gayle and Miller 2009, 2015; Gayle, Golan and Miller 2015; Li 2017). We contribute to this literature by analyzing misstatements as an equilibrium time-varying hidden action that can affect firm value but is randomly detected each period. The firm designs optimal contracts anticipating the manager's misstatement choices.

Before we enter into greater detail of our model, the problem raises an obvious question: what do we gain from a structural model, with the heavier economic restrictions it requires, to quantify the effects of accounting manipulation? To answer this, let us first take in facts collected in prior literature and discuss how economic restrictions help us weave these facts into a single theory and interpret economic magnitudes.

A first piece of evidence about corporate misbehavior is contained in the work of Karpoff, Lee and Martin (2008). They examine a large set of DOJ and SEC enforcement actions involving corporate misconducts. They find that enforcement mechanisms are indeed at play in such cases, with nine out of ten managers losing their job by the end of the action and mean (median) wealth loss due to decrease in stock prices of \$48.4 million (\$4.8 million). At the other side of the trade-off, a second piece of evidence can be found in the studies by Burns and Kedia (2006) and Bergstresser and Philippon (2006). These studies tell us that incentives are powerful determinants of observed accounting manipulations and, therefore, contracting relationships will play a role when explaining restatements.

Putting both incentives and enforcements together in a single theory is difficult without a structural model, because the manager will evaluate the benefit of current incentives versus random potential enforcements. This is the first role of our structural model: to bring together two different sources of data about the benefits and costs of misstatements into a single empirical model. Another empirical challenge is that we do not see all misstatements or what contracts would have been absent misstatements, so quantifying these primitives requires assumptions about the choice set of the manager. This is the second role of the structural model: to recover information about the causes of misstatements from a subsample of observed restatements.

In this draft, we conduct preliminary estimates of the model within a sample of large public US firms in which serious restatements were observed (see data section) and, for now, estimating four out of ten primitive parameters of the model - the remaining are set to values estimated in prior literature. These are highly preliminary but serve to illustrate magnitudes captured by our model. Overall, distortions due to misstated earnings are not as dramatic as surveys would suggest (Graham, Harvey and Rajgopal 2005) but they are not as insignificant as sometimes argued in the accounting literature (Ball 2013). Our initial estimates are that about 1% of earnings are misstated and such misstatements imply total distortions of about 18 basis points. To set ideas, for a market capitalization in the NYSE of about \$20 trillion, this represents about \$360 billion, several orders of magnitudes above the funding of the Securities and Exchange Commission (around \$1.5 billion).

Related literature. Within the contracting literature, there is a growing literature examining dynamic contracts in continuous-time (DeMarzo and Sannikov 2006; Biais, Mariotti, Plantin and Rochet 2007; DeMarzo and Fishman 2007; Sannikov 2008). From a modelling perspective, our model itself borrows closely from DeMarzo and Sannikov (2006), which offers a tractable continuous-time formulation of the optimal contracting problem without earnings manipulation. We modify their model to consider random detection of misstated reports - in this framework, the manager controls the amount of manipulation and the principal dynamically adjusts the level of incentives. Our model is closely related to DeMarzo, Livdan and Tchistyi (2013) who study a setting in which the manager may boost short-term performance thereby causing the risk of a financial disaster. In their setting, manipulation is binary, hence bounded, so unlike in our setting, turnover does not need to be random.

With the notable exception of Nikolov and Schmid (2012), who estimate a version of DeMarzo, Fishman, He and Wang (2012) with dynamic contracting and optimal investment, we are not aware of other works that use these models for structural estimation. This is partly surprising because two side benefits of these models are (i) to be computationally tractable, which is required for the large number of value function evaluation required for structural estimation and (ii) to offer rich and empirically-plausible predictions about firm dynamics that fit data better than static models. In this respect, our objective is to bring recent developments in dynamic contracting theory into existing research on structural estimation of CEO compensation (Taylor 2010, 2013).

There is, naturally, a much broader literature which examines manipulation with optimal contracting, see, for example, Dye (1983), Gigler and Hemmer (2001), Chen, Hemmer and Zhang (2007), Peng and Röell (2008, 2014), Evans and Sridhar (1996) and Caskey and Laux (2016). These theoretical models contain the theoretical ingredients that we incorporate into our dynamic model. We chose the current approach relative to these other models because it can accommodate with some tractability contracting dynamics that are present in the data but many of the economic intuitions at play in our model can also be found in these earlier studies.[1]

A vast number of empirical studies have examined properties of accounting restatements and this literature is too large to review in its entirety, so we focus primarily on topics that speak to elements of our approach. A stream of literature shows that the amount of manipulation depends on the ability of the manager to cash in from manipulation, which plays a key role in our analysis. In particular, Efendi, Srivastava and Swanson (2007) shows that manipulation increases when the manager has in-the-money options, since such are cases where the benefits of manipulation may be extracted. Edmans, Fang and Lewellen (2017) further show that managers engage in real earnings management, via reduced investment, near equity vesting dates. Consistent with these prior studies, how much funds the optimal contract lets the manager extract is key to manipulation incentives, since what is still tied

[1] Starting with Dye (1988), there is also an extensive literature with earnings management for pure reporting motives (i.e., managers maximize current price). The models of Fischer and Verrecchia (2000) and Dye and Sridhar (2004) are classic examples of earnings management by a price-maximizing manager, holding incentives as exogenous. See also Beyer, Guttman and Marinovic (2014), Terry (2015), Zakolyukina (2017) for recent examples of studies estimating misreporting in environments where managerial incentives are exogenous.

to the firm may be, in our model, retaken conditional on a misstatement.

In accounting, a large existing literature offers indirect evidence that firms set their earnings strategically, see, e.g., Dechow, Sloan and Sweeney (1995), Burgstahler and Dichev (1997) or Armstrong, Foster and Taylor (2015) and our study intends to contribute to this literature as well. The main focus of this literature is to provide tools to measure earnings management at the firm level, thus offering metrics to help predict misstatements. Our focus is indifferent here, in that we take the detection process as a given and attempt to unravel the consequences of manipulation over the entire population of firms.

1 The Model

We develop a parsimonious continuous-time principal-agent model, in which a manager can privately manipulate earnings but is subject to a probability of detection. The manager can also divert cash flows (i.e., shirk).

The firm operates over an infinite horizon $t \in [0, \infty)$ and generates a true cash flow, before cash diversion, of

$$dY_t = (\mu - \lambda m_t)dt + \sigma dB_t, \tag{1}$$

where $\mu > 0$ is a drift parameter capturing the natural growth rate, $m_t \in [0, \bar{m}]$ is the manager's manipulation, $\lambda > 0$ is the real cost of manipulation, σ is the volatility of cash flows and B_t is a standard Brownian motion. Hence, the firm's expected cash flow, before cash diversion, is $(\mu - \lambda m_t)dt$.

The true cash flow Y_t is observed by a risk-neutral manager with limited liability. The principal only observes the manager's report dX. If the manager does not divert cash flow, the manager's report is given by

$$dX_t = (\mu + \theta m_t)\, dt + \sigma dB_t, \tag{2}$$

where $\theta > 0$ is the reporting effect of manipulation. This parameter captures the manager's ability to inflate reported performance, hereafter, manipulation.

In addition to manipulating performance, the manager can divert cash flows for his own private benefit, which we can interpret as shirking, or more generally, any managerial action that provides a private benefit at the expense of firm value. By diverting one unit of cash flow, the manager obtains utility $\phi < 1$. Cash diversion is inefficient and, as in DeMarzo and Sannikov (2006), the optimal contract must discourage this behavior.

Manipulation may trigger a restatement and cause the manager to be fired. Formally, a restatement is a public signal represented by a Poisson process with intensity κm_t^2. We exogenously assume that a manager cannot continue with the firm when caught manipulating and, since there is no restatement absent manipulation, the firm must fire the manager.

In our model, restatements only occur conditional on manipulation so the firm imposes the harshest penalty (Piskorski and Westerfield, 2016) - hence, the fired manager leaves the firm with zero continuation utility (the limited liability). As we will see, the manager can also be fired because of poor performance because, then, incentives to manipulate are too high and, similarly, the manager leaves the firm with zero continuation utility. We assume that there may a cost to replace the manager and an additional cost to the firm if there is a restatement. Hence, conditional on firing for bad performance, the firm resets at a continuation utility level γ while conditional on firing due to a restatement, the firm resets at a continuation utility level $\ell < \gamma$.[2]

A contract prescribes realized pay C, manipulation m, and cash diversion U processes adapted to the filtration of X. Because of limited liability, the realized pay process must be non-decreasing. We further assume that the manager can privately save and, without loss of generality, restrict the attention to contracts that do not induce private savings.

As noted earlier, management turnover may be caused by a restatement or by low performance. We denote the termination time due to restatements by τ_R and the termination time due to low performance by τ_F. Accordingly, turnover occurs at time $T \equiv \min\{\tau_R, \tau_F\}$. As in Varas (2017), the presence of manipulation makes random termination optimal when the promised utility hits a certain bound. In the optimal contract, both τ_R and τ_F are double stochastic Poisson processes.[3] As usual, we can summarize the incentives of the agent using the agent's continuation value W_t, which is given by

$$\begin{aligned} W_t &= E_t\left[\int_t^T e^{-\rho(s-t)} dC_s\right] \\ &= E_t\left[\int_t^\infty e^{-\rho(s-t)-\int_s^t \kappa m_u^2 du-(A_s-A_t)} dC_s\right], \end{aligned}$$

where the compensator of τ_R is given by $\int_0^t \kappa m_t^2 dt$ while compensator of τ_F is given by A_t. In this equation, the agent's continuation W_t equals the expected present value of the compensation flow (i.e., realized pay).

Discussion. Our model is a dynamic multi-tasking problem because the manager can take two hidden actions: cash diversion and manipulation. In the absence of cash diversion (when $\phi = 0$), the manager's compensation is not sensitive to reported performance, hence manipulation is not an issue. When $\phi > 0$, the manager continuation value becomes

[2]We will estimate ℓ but do not require it to be exogenous. For example, we can close the model by assuming that $\ell = \max_w F(w) - c$ where c is a cost of finding a new CEO and $F(w)$ is the firm's value function as a function of the utility promised to the agent. Empirically, this relationship does not help estimate the model because, while it adds one restriction, it also adds an additional unknown, c. The same note applies as well to closing $\gamma = \max_w F(w) - c - c'$ where c' is an additional cost of restatements (e.g., shareholder lawsuits, SEC fines, etc.). In further analyses, we plan to use these restrictions to recover c and c' from the structural estimates.

[3]See Brémaud (1981) for a treatment of doubly stochastic counting processes.

sensitive to performance (β_t >0) or else the manager engages in cash diversion. But this also creates incentives to misreport current earnings. Deferring compensation helps solves both problems, by keeping more skin in the game and increasing risky when the manager is caught misreporting. As a result, the manager has fewer incentives to misreport with a higher promised utility. The principal can also to fire conditional on bad performance to avoid reaching states where manipulation incentives are very high. But turnover can also exacerbate manipulation near the firing threshold: the manager will engage in manipulation to avoid being fired. To mitigate this problem, the contract implements random turnover when performance falls below a threshold.

Our model postulates the probability of restatement is a function of the manipulation flow m_t, rather than the stock of manipulation as in Marinovic and Varas (2017). This is a somewhat unrealistic but necessary simplification because the problem of random detection would become intractable as it would entail persistent private information (Williams 2011). Intuitively, we may think that recent transactions are the easiest to capture and, indeed, many accounting frauds are first caught based on transactions recorded in the current year rather than a historical review of past transactions. Or, we may think of this assumption as representing the fact that manipulations reverse over time so that in steady state there is never a large gap between current and cumulative manipulation. Implicitly we assume that the gap between reports and cash flows persists until a restatement or turnover is observed. Hence, the main reversal mechanism of the manager's manipulation is turnover, consistent with a big bath after a manipulation is discovered and a new CEO issues a restatement.

2 Data Description

The sample is constructed from merging company financials from Compustat Annual, price data from CRSP, restatement from Audit Analytics into CEO compensation data from Compustat Execucomp with non-missing assets and net income.

Because we are primarily interested in restatements identified as management wrongdoing in large visible firms, we apply a number of filters to this database. First, we eliminate restatements caused by out-of-period adjustments, which refer to corrections of small immaterial errors, as well as one-time restatements due to SAB 108 and FIN 48, two regulations passed in 2006 which required restatements under a revised materiality guidance and for previously omitted tax risks, respectively. We further restrict the sample to firms covered by Compustat Execucomp. This subsample of Compustat accounts for about 66.5% (in 2015) of the market capitalization of US firms traded in the three major exchanges and consists in firms with non-trivial of regulatory scrutiny and press coverage.

We obtain restatement effects from three different data files in Audit Analytics. The file *restatement_periods* contains per-period income effects (variable *change_net_income*) for the time span 2000 to 2016. Because filings may repeat restatement effects per restatement, or a restatement amount may be stated in quarters and years, a restatement effect is included only if the variable *include_in_income_calculations* is marked as one.

However, the sum of changes in net income does not equal the cumulative restatement effect in the Audit Analytics restatement file *feed39*, in which each observation is a restatement filing. This occurs because, under US GAAP, a firm need only restate past periods separately for at most five years or less when information is unavailable or effects are not material relative to the current period. To address this, Audit Analytics provides the restatement plug effect in the *restatement_filings* file which contains the effect on all periods that are not separately reported.

To allocate the plug, we use information about the start of the restatement in *feed39*, which is given by the variables *cum_begin_date* and *cum_end_date* and identify years not reported in *restatement_periods* overlapping this span. If at least one year is missing, we allocate the plug equally over all missing years, creating additional restatement years for each year of the restatement span. If *cum_begin_date* is missing or greater or equal than the minimum restatement year in the *restatement_periods* file, we allocate the entire plug to one year before the minimum restated year.

Since our model captures only income-increasing activities, we remove all under statements, taking out firm-year restatements that increase current income. In practice, these can refer to activities in which a manager benefits from lower income (big bath) or reversals of prior misstatements. Because many restatements are not major corporate events and refer to bookkeeping errors that are not directly caused by management action (Hennes, Leone and Miller 2008), we comb public sources of information for serious investor reactions or regulatory responses. We say that restatements in a firm are serious if one restatement or restated firm-year meets one of the following criteria:

1. A restatement announcement (filing date) features a 3-day return around the restatement filing date below -10%; if the latter is missing (i.e., the stock is not traded), we use the shortest trading window that includes the restatement filing date.

2. The change in net income in the firm-year due to the accounting restatement is at least 5% of one of current assets or equity.

3. Based on the Stanford law school shareholder lawsuit database, the firm was sued at least once during the period 2000-2016. Unfortunately, lawsuits do not always specifically refer to a particular restatement period, so we use the existence of a lawsuit. The Stanford database reports companies named in the lawsuit. We extract the first named defendant and match to compustat after deleting standard company identifiers (e.g., inc., corp., industries, etc.) which can appear differently across databases or

	All firms		Restatement firm-years		
	Obs.	Unique firms	Obs.	Unique firms	Total abs. restated (bil. USD)
Full Compustat sample (2000-2017)	156,581	17,956	9,950	2,918	1,139
covered by Execucomp	25,335	2,434	3,530	936	134
meets one of criteria (1)-(5): AAER, shareholder lawsuit, large negative 3-day filing return, fraud or regulatory investigation or >5% of balance sheet item			1,648	397	119
must be an overstatement			1,048	309	110
more than .5% of balance sheet item			653	251	109
departing top executive around misstatement			637	239	105
removed outlier (MCI Inc.)	25,332	2,433	635	238	37
Final sample	**25,332**	**2,433**	**635**	**238**	**37**

Table 1: Sample construction

when a subsidiary with the same name is sued.[4]

4. The firm received an Accounting and Auditing Enforcement Release (AAER) by the SEC referring to at least one year in the restatement filing. We obtain the firm-years with an AAER from the Center for Financial Reporting and Management at Berkeley (see Dechow, Ge, Larson and Sloan 2011 for details) extending the database from September 30th 2016 to December 31st 2016. Alternatively, the restatement filing mentions fraud or investigation by a regulatory agency, as indicated by the variables *res_fraud*, *res_sec_investigation* and *res_regulatory_investigation* in Audit Analytics.

Then, among all remaining restatement observations, we apply an additional filter to remove restatements that did not have consequential effects on a firm or the career of its top executive. First, we remove all restatements in firm-years that were less than half of a percent of assets or equity. Second, we remove restatements for careers that did not have at least one restated year during, prior or after the last year of a CEO in the sample. Third, we remove one outlier, MCI Inc., which accounts for two thirds of the total amount restated in the remaining sample.

Table 1 outlines the sample construction. Our final sample includes 635 restated firm-years in 238 unique restatement firms, out of 25,332 firm-years in 2,433 unique firms. Serious restatements in large firms are uncommon, at about 2.5% of firm-years. At a firm level, however, 9.7% of all firms had at least one serious restatement. Recall, however, that all executives manipulate in our model and, if the probability of detection is low, these detected misstatements may imply much larger magnitudes for undetected misstatements. The total

[4]The code is available on request from the authors.

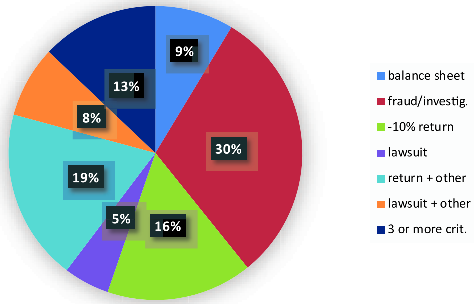

Figure 2: Breakdown of restatement firm-years

amount restated in our sample was \$37 billion, which corresponds to about about half a trillion dollars in implied market capitalization assuming a P/E ratio of 15.

Figure 2 provides an overview of the reasons why a restatement is categorized as serious in our sample. Roughly half of the sample is serious on more than one category. Among restatements with only a single category, the largest fraction of restatements is categorized as serious because of fraud or regulatory investigation (30%), and the second largest is at least -10% market return around the filing date. Lawsuits are the least common unique category, at 5%, which comes from the fact that many lawsuits occur concurrently with other variables: in total 13% of restated firm-years are in a firm with a shareholder lawsuit during the sample period.

A key variable for our research question will be the value paid off to the manager since it can no longer be taken from the manager conditional on a restatement. In practice, a large portion of executive wealth remains tied to the firm in the form of unvested equity (Core, Guay and Larcker 2003), so the value effectively paid can be quite different from pay. For example, a change in the value of unvested options would capture compensation during a period but not value paid to the manager. To capture this economic variable, we measure and report the total current compensation in Execucomp (for the most part, compensation paid in cash) plus the total value of option exercised, since this is compensation that is no longer contingent on continued employment. Hereafter, we refer to this quantity as realized pay.

To calculate the total loss to a manager due to firing, we calculate three parts: (i) the total wealth in unvested equity which, we assume, is entirely lost conditional on a firing due to a serious detected misstatement, (ii) the loss due to forced exercise of vested options, and (iii) the opportunity cost of lost future pay.

To calculate (i) and (ii), we obtain estimates of the portfolio of options from Execucomp. For data post 2006, Compustat records options outstanding at the end of the fiscal year. We use the Black-Scholes equation to approximate the fair value of each option of each option.[5] As inputs for this equation, we use historical return volatility from the one-year window between earnings announcements, the risk-free rate from the yield curve in the Option Metrics database, matching the yield curve to the time remaining on the option until maturity. We sum over the total value of the option portfolio each year, and calculate the change in the value of the option portfolio. To this, we add the the total value due to exercizes (variable *opt_exer_val*) to obtain the change in wealth due to options.[6]

For data prior to 2006, we do not observe individual portfolios but aggregate values about managerial options which take the form of total number of options in the money, total number of options out-of-the-money, as well as total fundamental value of all options in the money. We use the methodology outlined in Core and Guay (2002) to derive a synthetic option portfolio consistent with this data. In short, the method involves constructing an implied portfolio composed of one option in-the-money and one option out-of-the-money, where the strike of the in-the-money option is inferred as the average fundamental value of the option by the number of the in-the-money options, and all other variables are inferred from characteristics of current option grants. A summary of the procedure can be found in Coles, Daniel and Naveen (2013). Using hand-collected data, Core and Guay (2002) suggest that this method provide a good approximation of the actual portfolio sensitivities and, given that we do not directly observe line-by-line exercises prior to 2006, some inference procedure from public data sources is necessary. After we compute these synthetic options, we follow the same construction as for the post 2006 data. For restricted shares, we observe the total amounts owned as unearned restricted shares and equity incentive plan shares, as well as total amount vested.

Then, total unvested equity, or component (i), is obtained by aggregating the value of unvested options and restricted shares. The loss of forced exercise due to firing, or component (ii), is obtained as the difference between the fair value of vested options minus their value if exercized (i.e., the difference between current price and strike price). The opportunity cost of lost future wages, or component (iii), is obtained by first running a fixed effects panel regression of realized pay on tenure, and using the predicted realized pay to complete future years of each manager in the sample conditional no being employed. Then, we estimate the probability of exogenous turnover by age (i.e., the average probability of staying with the firm for each CEO age). We then obtain the opportunity loss *OppLoss* iteratively by discounting future realized pay at 3%,

$$OppLoss_{t,i} = (1 - \hat{p}_{t,i}) * (OppLoss_{t+1,i} + \hat{c}_{t+1,i})/1.03,$$

[5] Empirical analyses of option exercises for CEOs documents that managers exercise early, but do so typically when the fundamental value is around 99% of the true value, which suggests that, as an empirical fact, Black-Scholes might offer a good approximation of the monetary gains to the manager.

[6] Note that we do not add the value of new option grants, because this is already captured via the change in the value of the option of portfolios.

where $\hat{p}_{t,i}$ is the average probability of turnover in the age group of manager i at date t and $\hat{c}_{t+1,i}$ is the predicted realized pay at date $t+1$ for manager i. Because there is not enough data to estimate $\hat{p}_{t,i}$ at high age brackets, we set $\hat{p}_{t,i} = 1$ for any manager above 75 years old.

Variable	Obs.	Mean	s.d.	min	p25	p50	p75	max
Full Sample								
Firm characteristics (in bil. USD)								
Assets	25,332	7.4	26.33	0	0.53	1.55	5.02	797.77
Equity	25,263	2.66	8.66	-85.34	0.24	0.62	1.81	181.06
Market cap.	25,100	7.66	25.96	0	0.53	1.47	4.72	629.01
Net income	25,332	0.33	1.96	-98.7	0.01	0.06	0.23	53.39
1 year return	24,692	0.08	0.2	-0.56	-0.01	0.11	0.18	2.66
CEO characteristics (in mil. USD)								
consumption	25,332	3.8	27.66	0	0.67	1.08	2.56	3299.7
tenure at turnover	2,705	7.69	7.38	0	2.67	5.87	10.3	61.79
cum. consumption at turnover	2,705	18.97	58.39	0	1.89	5.55	17	2047.5
cum. net income at turnover (in bil.)	2,705	1.54	9.08	-78.83	-0.02	0.14	0.81	216.75
Restatement firms								
Firm characteristics (in bil. USD)								
Assets	2,999	8.28	50.73	0.01	0.5	1.2	3.41	797.77
Equity	2,993	2.23	10.72	-5.29	0.19	0.48	1.25	155.62
Market cap.	2,981	6.26	34.71	0	0.45	1.06	3.01	629.01
Net income	2,999	0.2	3.01	-98.7	-0.01	0.03	0.13	53.39
Restated income (in mil)	635	-58.46	247.22	-4907	-28.36	-9.54	-3.64	0
CEO characteristics (in mil. USD)								
consumption	2,999	2.6	6.83	0	0.62	0.99	1.9	116.43
tenure at turnover	389	7.08	7.39	0	2.04	5.08	9.09	48.86
cum. consumption at turnover	389	12.04	23.17	0	1.72	4.31	11.1	174.33
cum. net income at turnover (in bil.)	389	0.12	5.93	-78.83	-0.15	0.03	0.26	60.99
Manager wealth loss when fired								
Opportunity loss	25332	24.06	14.37	0	15.2	23.64	33.1	83.82
unvested equity	25332	11.71	30.72	0	1.15	4.51	12.2	1518.8
vested equity (forced exercise)	25332	2.86	8.46	0	0	0.69	2.63	537.04
Total loss	25332	38.62	37.12	0	22.47	33.73	47.2	1617.2

Table 2: Descriptive statistics

In Table 2, we provide some descriptive statistics on our sample. Firms covered in Execucomp are large, with a mean of \$7.4 billion in assets and \$7.66 billion in market capitalization. The median firm has assets and market capitalization around \$1.5 billion, which means that it is relatively visible to the general public. CEOs in this sample realized a realized pay of \$3.8 million per year and stayed with the firm for an average of 7.7 years. Over their career, they realized \$18.97 million and a cumulative average \$1.54 billion in net income. In the subsample of firms with at least one serious restatement, restated income per year was −\$58.5 million on average, with median of −\$9.6 million. Executives in restating firms had slightly shorter careers and reported lower income, at \$200 million per year versus \$330 million in non-restating firms.

The compensation variable and, to even larger extent, the restatement amounts are subject to scale effects as the contribution of the manager may be different in larger firms (Edmans, Gabaix and Landier 2008; Edmans, Gabaix, Sadzik and Sannikov 2012). Un-

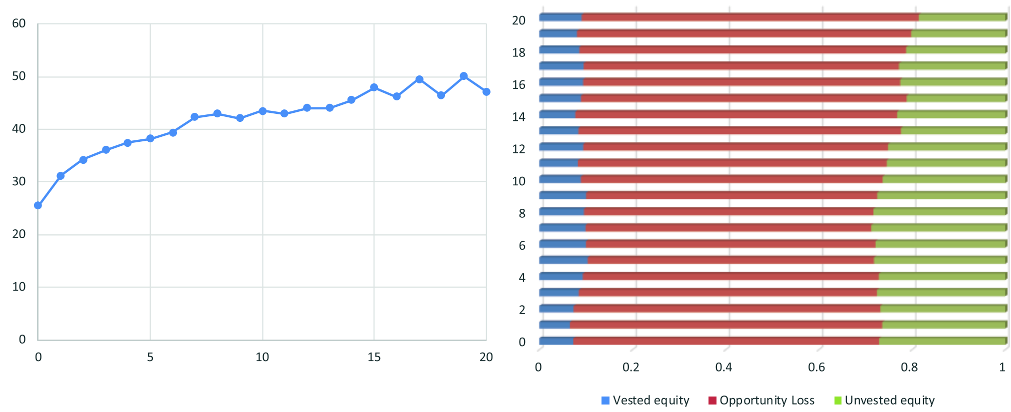

Figure 3: Losses due to firing

fortunately, addressing changes in scale endogenously from within the model is non-trivial because, if managerial actions (hence, detection rates) consider scale, the contract and detection will look ahead to future scale when choosing the amount of manipulation to elicit. Instead, we address scaling in reduced-form by dividing each dollar variables by a scaling factor. Scaling by current balance sheet variables is problematic because the utility of the manager should not scale with the firm throughout a career and firm equity is endogenous to the manager's reporting choices. For this reason, we scale by lagged assets at the first year of a CEO in the sample, where lagged assets are winsorized at the top and bottom 1%.

In the last three rows of Table 3, we report the total loss conditional on firing and its three components. A typical CEO in our sample would lose $38 million conditional on being fired. The larger portion of this loss, about $24 million, is caused by the manager's opportunity cost of future lost compensation - this is intuitive because, at a realized pay of $2.6 million per year, this component is larger than the portfolio of unvested equity for most CEOs. About $11 million is due to the loss of unvested equity (options and restricted shares) and, lastly, a relatively small amount, about $3 million, is due to the forced exercise of vested options, which forfeits the remaining time value of these options.

Figure 3 further reports how these components evolve over a typical tenure. On the left-hand side, total loss increases over a twenty year tenure, which is consistent with the deferral of wealth predicted by our model. A components of this wealth loss increase over time but the opportunity cost tends to play relatively a large share over time, as the probability of firing decreases with tenure, increasing the weight of future periods - this portion only reduces toward very long tenure due to the effect of age.

Table 3 reports the Spearman correlation matrix of scaled net income, realized pay, restatement amount, turnover and a restatement firm-year indicator variable. As expected, 1-year returns, realized pay and net income are positively correlated, and they are negatively correlated to turnover. We also expect in the model restatements to occur conditional on bad performance, and find a restated year is indeed more likely when the net income is high, although we do not find this in returns. Lastly, turnover is more likely when there is a restated firm-year which is consistent with our model hypothesis that restatements are tied to executive turnover.

	consumption	net income	return	turnover	restated amount	restated year
consumption	1					
net income	0.4651***	1				
return	0.0169***	0.0642***	1			
turnover	-0.0141**	-0.0592***	-0.0144**	1		
restatement amount	-0.0151**	-0.0722***	-0.0110*	0.0257***	1	
restated year	-0.2334**	-0.1155***	0.0935**	0.0715*	.	1

Table 3: Correlation Matrix

3 Analysis

At any time $t < T$, we have the following representation for the evolution of the agent's continuation value.

Lemma 1. *For any $t < T$, there is an adapted process β_t, measuring the sensitivity of the continuation value to performance, such that*

$$dW_t = \left(\rho + \kappa m_t^2\right) W_t dt + \beta_t [dX_t - (\mu + \theta m_t)\, dt] - dC_t + W_t dA_t. \tag{3}$$

The continuation value W_t changes due to several factors. The first term captures promise keeping: the continuation value must increase at a rate equal to the manager's discount factor plus the rate of restatement arrivals. The second term is the pay-for-performance component: performance surprises are rewarded at a rate β_t. The third term dC_t captures the reduction in continuation value due to incentive vesting, namely, when the manager consumes. The fourth term $W_t dA_t$ represents extra incentives given to a poorly performing manager, if not fired, to keep the continuation value W_t above a minimum level required for employment.

Next, we consider the manager incentives to report truthfully and manipulate. As in DeMarzo and Sannikov (2006), the manager has an incentive not to steal cash flows when receiving at least ϕ of continuation value for each reported dollar, or

$$\beta_t \geq \phi.$$

When $\beta_t > 0$ the manager has an incentive to manipulate reported performance. However, this can lead to a restatement resulting in firing and a loss the continuation value. Given continuation utility W_t, the manager's optimal manipulation is

$$m_t = \arg\max_m \{\beta_t \theta m - \kappa m^2 W_t\} = \frac{1}{2}\frac{\theta\beta_t}{\kappa W_t}.$$

The following Lemma summarizes the incentive compatibility constraint.

Lemma 2. *A contract (m, C, A) with sensitivity β is incentive compatible if only if for all $\tau < T$, $W_t \geq 0$ and*

$$\beta_t \geq \phi, \tag{4}$$

$$m_t = \frac{1}{2}\frac{\theta\beta_t}{\kappa W_t}. \tag{5}$$

A marginal increase in manipulation allows the manager to increase the continuation utility by $\beta_t\theta$ but – by increasing the likelihood of a restatement – it increases the expected loss by approximately $2\kappa m_t W_t$. From the manager's viewpoint, the cost of manipulation is given by the possibility that a restatement leads to termination and destroys any unvested compensation - the continuation utility in (5).

Given the agent's continuation value w_0, the principal's contracting problem can be written as

$$F(w_0) = \max_{m,C,A} \; E_0\left[\int_0^T e^{-rt}\left[(\mu - \lambda m_t)\,dt - dC_t\right] + e^{-rT}\left(\mathbf{1}_{\{T=\tau_R\}}\ell + \mathbf{1}_{\{T=\tau_F\}}\gamma\right)\right]$$

subject to (3), (4) and (5).

This expression captures the present value of the firm's cash flows net of the manager compensation dC. Upon termination, the principal receives γ if termination is caused by a restatement or ℓ if termination is caused by low performance. The principal's value function $F(w)$ solves the HJB equation

$$rF(w) = \mu - \lambda m(w) + \kappa m^2(w)(\gamma - F(w)) + (\rho + \kappa m^2(w))wF'(w) + \frac{1}{2}\sigma^2\phi^2 F''(w).$$

The first term of the right hand side, $\mu - \lambda m$, captures the firm's cash-flow net of the effect of manipulation. The second term captures the capital loss when a restatement hits. The third term captures capital gains arising from the drift of the agent's continuation value: changes in the agent's continuation value affect the severity of the agency friction hence the principal's expected payoff. The last term is a risk premium, arising because the principal's value is concave in W. Among other things, volatility is costly to the principal because it causes inefficient termination.

The optimal contract specifies two boundaries for the agent's continuation value: a lower boundary w_l where the agent is randomly terminated and a payment boundary w^u where the agent is paid in cash and consumes. Also, the manager is fired stochastically whenever W_t is reflected at w_l. Whenever W_t hits w_l, $dP_t = \max(0, w_l - W_t)$ is added to the agent's continuation value. The intuition for this policy is straightforward. If the agent were fired with probability one at the boundary, then incentives to manipulate would become infinite near w_l causing infinite losses to the firm. Vice-versa, if the firm were to increase the probability of firing smoothly when reaching closer to w_l, then there would be some gains to be made by shifting more firing probability to the boundary. The optimal solution to this problem is to fire with non-zero probability at the boundary (Daley and Green 2012). Since firing yields a non-marginal drop in continuation utility to zero, which is below w_l, the promise-keeping constraint requires the non-firing event requires a continuation utility that is strictly greater and bounded away from w_l. In other words, we can think in practical terms about w_l as a point where the manager meets with the board and, if not fired, is given a second chance with a new level of continuation utility.

As is usual in this literature (Sannikov 2008; Demarzo and Sannikov 2016; Varas 2017), the value function must satisfy the smooth pasting and super contact conditions at the boundaries to be optimal: at the upper boundary,

$$
\begin{aligned}
F'(w_u) &= -1, \\
F''(w_u) &= 0.
\end{aligned}
$$

and the lower termination boundary w_l,

$$
\begin{aligned}
F(w_l) &= \ell + w_l F'(w_l), \\
F''(w_l) &= 0.
\end{aligned}
$$

Finally, the principal chooses w_0 to maximize his continuation value, hence

$$
w_0 \equiv \arg\max_{w} F(w).
$$

Note that we implicitly assume that the principal has enough bargaining power, because the manager receives positive rents given the limited liability assumption - in other words, our results would be unchanged as long as the manager did not have enough bargaining power to obtain a continuation utility above w_0. As we shall also see, the ability to manipulate reports may increase the manager's rents.

As a benchmark, when $\theta = 0$ the manager has no ability to manipulate reports and our model reduces to DeMarzo and Sannikov (2006). Then, since the manager cannot

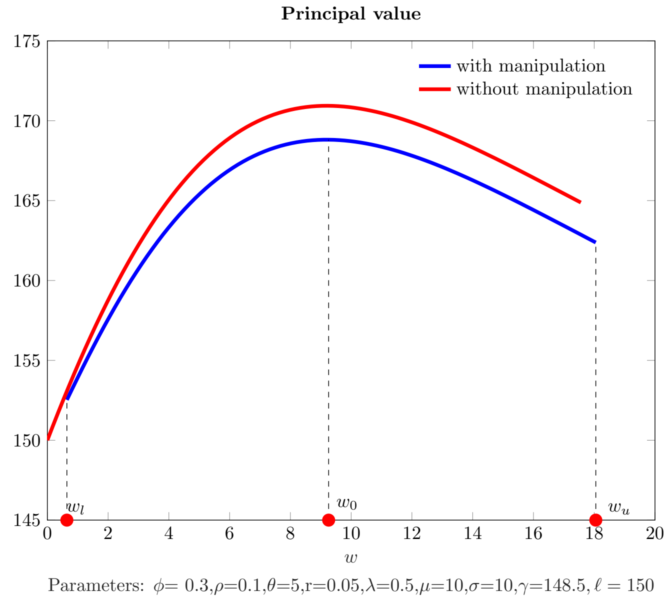

Figure 4: The principal continuation value $F(.)$ with and without manipulation. The red curve captures the case when the manager does not have an incentive to inflate reports ($\theta = 0$). The blue curve captures the case when the manager has the ability to manipulate reports ($\theta > 0$). Naturally, the ability to manipulate reports reduces the principal value $F(w_0)$. By contrast, the manager continuation value w_0 may be higher thanks to the ability to manipulate reports, because of limited liability. It's also apparent from this figure that the ability to manipulate reports affects the manager's turnover. When continuation value hits the lower boundary (w_l) the manager is terminated randomly. The possibility of manipulation also affects deferred compensation. Notice that under the possibility of manipulation the upper boundary w_u goes up.

manipulate, $m_t = 0$. Turnover becomes deterministic, given performance, and the solution of the principal's HJB is given by

$$rF(w) = \mu + \rho w F'(w) + \frac{1}{2}\sigma^2\phi^2 F''(w)$$

with boundary conditions

$$\begin{aligned} F(0) &= \ell \\ F'(w_u) &= -1 \\ F''(w_u) &= 0. \end{aligned}$$

4 Comparative Statics

Our model predicts that manipulation intensifies when the firm performance declines because the cost to the manager of being fired becomes smaller with less skin in the game. This prediction is apparent from inspection of the misreporting incentive constraint in equation (5). Further, good performance leads to longer tenure and milder manipulation.

To understand how the parameters affect the model's predictions, we provide some comparative statics. We focus on four parameters $(\kappa, \lambda, \rho, \phi)$ capturing the severity of moral hazard. Recall that: κ is the principal's detection ability; λ is the real cash flow effect of the manager's manipulation; ρ is the manager myopia; ϕ is the magnitude of cash diversion incentive; θ is the effect of manipulation on reported performance. We examine the effects of these parameters on four moments of the ergodic distribution, with expectation operator $\overline{E}$: the expected reported earnings $d\overline{E}(X_t)$, scaled by initial firm value $FV = w_0 + F(w_0)$; the intensity of restatements $\overline{E}(\kappa \cdot m_t^2)$; the expected cash compensation $E(C_T)$, scaled by initial firm value FV and tenure $E_0 T$. For these analyses, we use the estimates of Section 4 as benchmarks.

Figures 5 to 9 suggest that each primitive of the model has large effects on each of the moments. In figure 5, we plot each parameter as a function of the impatience of the manager. In this type of model, more compensation can be deferred when the manager is more patient, helping both the diversion and the manipulation problem. Vice-versa, as impatience increases, the contract relies more on turnover and pay-for-performance, also increasing incentives to manipulate. As a result, the report and the restatement intensity increase. Realized pay is increasing in impatience over most of the range, because the contract must pay more when deferring compensation - except for a small region at very low levels of impatience in which tenure is abnormally high and both problems are almost entirely solved.

In Figure 6, we examine the effect of an increase in detection intensity assuming, say, that regulators increase funding to a regulatory body or the board commits to a more effective auditor. Interestingly, while detection causes firing holding manipulation constant, an increase in detection ability increases tenures because it reduces equilibrium manipulation. Intuitively, firings are a costly tool to prevent manipulation so more monitoring reduces the use of this tool. For this same reason, restatement intensity and reported earnings also decrease. Because the informational friction that cause the manager to obtain rents is reduced, the realized pay received by the manager decreases and, in the limit with a very high detection rate, realized pay converges to the level required under pure cash diversion.

In Figure 7, we find that higher real effects of manipulation reduce the equilibrium manipulation, causing longer tenure and less frequent restatements. Real effects also reduce the value of the firm FV, so that, relative to the firm value, both reports and realized pay increase. Figure 8 further shows how tenure and restatements behave differently in response to accrual effects. Accrual effects of manipulation are beneficial to the manager because they generate reporting benefits holding real effects fixed. So accrual effects decrease tenure and increase the frequency of restatements. Lastly, cash diversion in Figure 9 increases the require pay-for-performance that must be given to the manager when employed, and magnifies misreporting incentives. We observe that this causes shorter tenure, more frequent restatements, higher reports and greater realized pay.

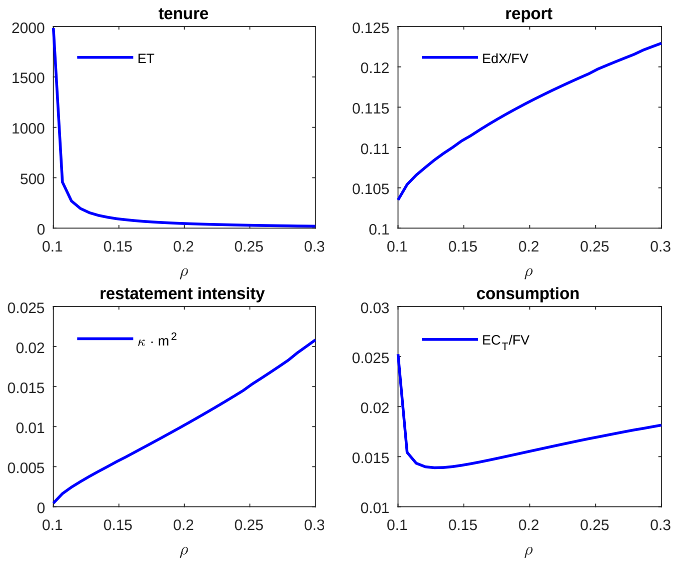

Figure 5: Effect of manager impatience (ρ).

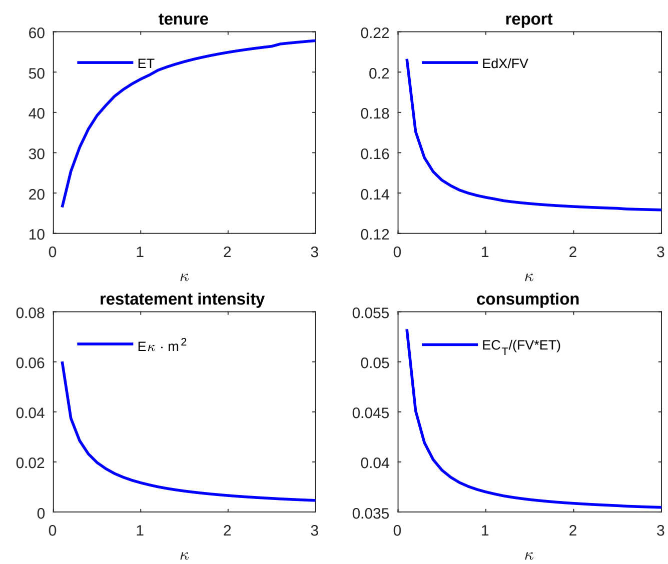

Figure 6: Effect of detection ability (κ).

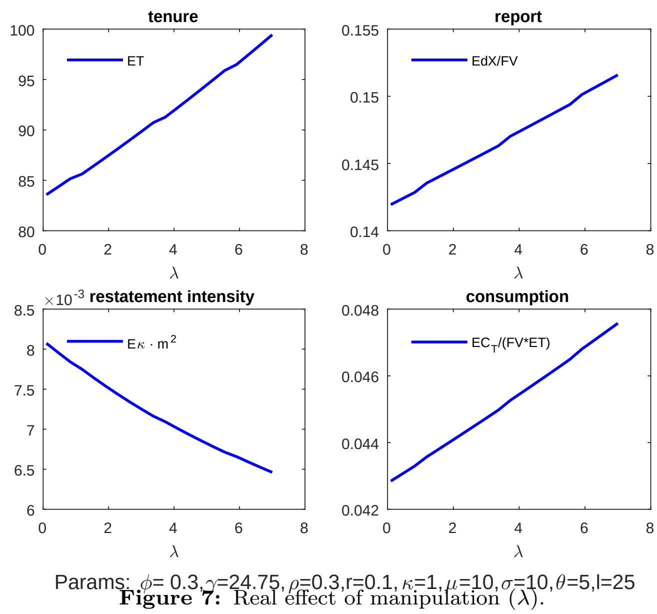

Figure 7: Real effect of manipulation (λ).

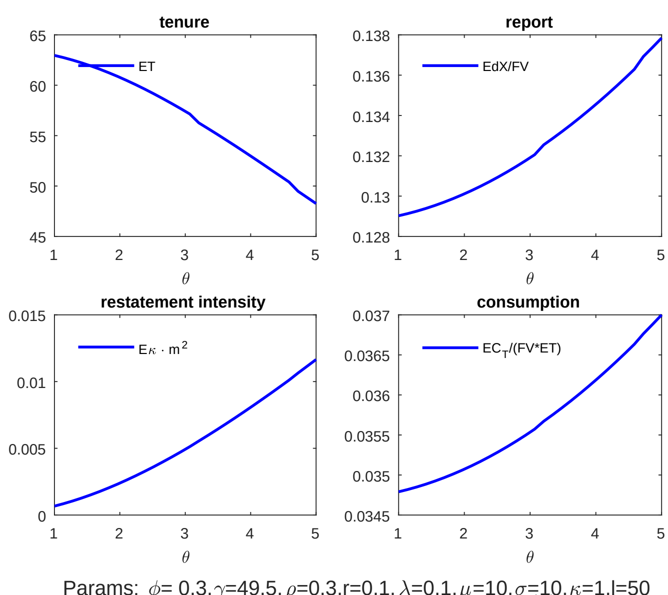

Figure 8: Accrual effect of manipulation (θ).

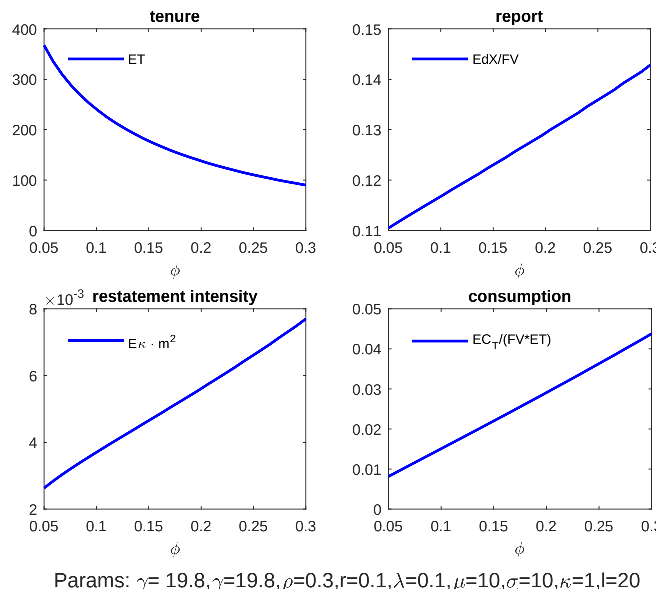

Figure 9: Effect of cash diversion (ϕ).

5 Estimation strategy

Our model has 10 parameters $\{r, \rho, \mu, \sigma, \theta, \lambda, \kappa, \gamma, \ell, \phi\}$. We conduct a preliminary estimation of four primary parameters capturing the severity of moral hazard, $(\kappa, \lambda, \rho, \phi\ )$.

Table 4: Parameters to estimate

parameter		interpretation
ρ	:	manager impatience
ϕ	:	cash diversion ability
κ	:	detection ability
λ	:	value destruction of manipulation

We set the value of the remaining parameters as reported in Table 5. We match the

Table 5: Calibrated parameters

parameter		interpretation	value
r	:	interest rate	5 %
μ	:	growth rate	10
σ	:	volatility	10
ℓ	:	cont. payoff after firing	$75\%\frac{\mu}{r}$
γ	:	cont. payoff after restatement	$99\%*\ell$

following four moments:

$$\begin{aligned} \text{tenure} &: \quad E\left(T\right) \\ \text{restatement rate} &: \quad \kappa\overline{E}(m_t^2) \\ \text{annual report} &: \quad \frac{\mu \ + \theta\overline{E}(m_t)}{FV} \\ \text{pay} &: \quad \frac{E\left(C_T\right)}{FV \cdot ET}. \end{aligned}$$

The theoretical moments are computed by solving the ODE of the model. Specifically, recall that the law of motion for the manager continuation value W_t is given by

$$dW_t = \left(\rho + \kappa m(W_t)^2\right) W_t dt + \sigma\phi dB_t - dC_t + dP_t.$$

Letting $h(w) = E_0(T|W_0 = w)$ be defined as the expected tenure at continuation utility w,

$$\Pr(T \geq t|\{w_s\}_{s\leq t}) = e^{-\int_0^t \kappa m(w_s)^2 ds - \frac{1}{w_l}P_t}$$

and

$$\begin{aligned} h(w) &= E_0\left(\int_0^T \mathbf{1}_{t<T} dt\right) \\ &= E_0\left(\int_0^\infty E_t(\mathbf{1}_{t<T}) dt\right) \\ &= E_0\left(\int_0^\infty e^{-\int_0^t \kappa m(W_s)^2 ds - \frac{1}{w_l}P_t}\right). \end{aligned}$$

Hence, $h(w)$ satisfies the following ODE

$$\begin{cases} \kappa m(w)^2 h(w) = 1 + \left(\rho + \kappa m(w)^2\right) w h'(w) + \frac{1}{2}\sigma^2\phi^2 h''(w) \\ h'\left(w_u\right) = 0 \\ h'(w_l) = \frac{h(w_l)}{w_l} \end{cases}.$$

We are also interested in the stationary expected reports and the rate of restatement. Let $p(w)$ be the stationary distribution of w. By the renewal theorem, we have that

$$\begin{aligned} \overline{E}\left[m(W_t)\right] &= \frac{E_0\left[\int_0^T m(W_t)dt\right]}{E_0[T]} \\ \overline{E}\left[m(W_t)^2\right] &= \frac{E_0\left[\int_0^T m^2(W_t)dt\right]}{E_0[T]} \end{aligned}$$

where $E_0[T] = h(w_0)$. Let $g_1(w) \equiv E_0\left[\int_0^T m(W_t)dt|W_0 = w\right]$ and $g_2(w) \equiv E_0\left[\int_0^T m^2(W_t)dt|W_0 = w\right]$. Like in the case of turnover, these functions are given by the differential equations

$$\begin{cases} \kappa m(w)^2 g_1(w) = m(w) + \left(\rho + \kappa m(w)^2\right) w g_1'(w) + \frac{1}{2}\sigma^2\phi^2 g_1''(w) \\ g_1'(w_u) = 0 \\ g_1'(w_l) = \frac{g_1(w_l)}{w_l} \end{cases}$$

and

$$\begin{cases} \kappa m(w)^2 g_2(w) = m^2(w) + \left(\rho + \kappa m(w)^2\right) w g_2'(w) + \frac{1}{2}\sigma^2\phi^2 g_2''(w) \\ g_2'(w_u) = 0 \\ g_2'(w_l) = \frac{g_2(w_l)}{w_l} \end{cases}.$$

From these equations we obtain the frequency of restatements, $\kappa\overline{E}\left(m_t^2\right)$, and the average report, $\mu + \theta\overline{E}\left(m_t\right)$.

We report the estimates of our model in Table 5. The ratio of λ captures the real value destroying effect of manipulation on long-term firm value relative to the reporting benefit. These estimates suggest that the real effect is not large, at about 1.5% ($\approx$ 5.137/0.079). These are also the magnitudes one would expect from prior literature on real earnings management (Roychowdhury 2006).

Table 6: Method of Moment Estimates

λ	κ	ρ	ϕ
0.018	0.104	0.371	0.292
(0.006)	(0.069)	(0.011)	(0.008)

There is also a relatively high probability of detection once manipulation becomes large and which is consistent with the relatively small average restatements in our sample - note that we do not match this moment. If the manager chooses $m_t = 1$ for one period, the probability of being caught will be approximately $\kappa m^2 = \kappa$. Given our estimates, this represents a reporting bias of 3.3% of firm value (θ/FV). To be more concrete, one million dollar is about 0.1% of firm value which in turn maps to a probability of being caught of $\kappa * 0.1\%/3.3\% = 7.6\%$.

We also estimate ρ, the impatience of the manager. This is a key parameter in our model because, if the manager were as impatient as the firm, it would be desirable to defer compensation indefinitely (DeMarzo and Sannikov 2006; Biais, Mariotti, Plantin and Rochet 2007) so this parameter drives the realized pay process of the manager but also, indirectly, the cost of deferring compensation (hence, the cost to the firm of real earnings management). We find that the manager is slightly more impatient than the firm, with a discount rate of 2.9% (0.079 − 0.05) higher than that of the firm. These estimates are fairly plausible given well-diversified individuals who are not yet retired and, while employed, tend to be relatively wealthy. For comparison, Arcidiacono, Sieg and Sloan (2007) estimate a subjective discount rate of 9%, slightly above our estimate.

Table 7: Estimated Payoff, Tenure, and Manipulation

F_0	w_0	$E(T)$	$\frac{\overline{E}(m_t)}{\mu+\overline{E}(m_t)}$
152.02	2.672	7.662	0.034
(0.068)	(0.067)	(0.201)	(0.002)

In Table 6, we recover several moments implied by the model. The expected tenure matches the moment in the data, at 7.6 years on average. The total value of the firm is \$154.7 million but, due to the limited liability, the firm must transfer \$2.7 million to the manager to provide incentives, causing a reduction of the principal's surplus to \$152 million. This is an analogue to the cost of providing incentives in Margiotta and Miller (2000) and, as noted in prior literature is a small component.[7]

Table 8: Counterfactual payoffs when the manager has no ability to manipulate earnings

F_0	w_0	ET
152.482	2.805	8.569
(0.073)	(0.065)	(0.209)

Table 7 and 8 contain the counter-factual analysis and measure the loss of welfare relative to an ideal economy where managers cannot manipulate earnings. In table 7, tenure would have been slightly above 8 years without manipulation and the value to the principal F_0 is slightly greater. In table 8, we compare the counterfactual in percentage terms. Firm value is reduced by 0.39% relative to an economy with no earnings management. For an average capitalization in our sample of \$6.26 billion, this represents a loss of value of roughly \$35 million per firm. Tenure is 11% longer without misstatements. We also find that the manager loses about 4.99% in lifetime utility when hired because of the possibility of misstatements - so misstatements hurt both managers and firms. This does not represent a large magnitude, however, at about 2.5 hundred thousand dollars in lifetime income.

In the last two columns, we report the implied replacement cost c_h from the relationship $\ell = F(w_0) - c_h$, i.e., on the left-hand side the utility of the firm when renewing a manager for bad performance and, on the right-hand side, the value implied by the new incoming manager minus the replacement cost. This cost comes at about 1.37% in our model. Similarly, we recover the exogenous cost of restatements from $\gamma = F(w_0) - c_h - c_l$. The direct cost of restatements is at about 1% of firm value. Note that these estimates imply that the primary channel through which manipulation causes losses *on the equilibrium path* is not via actual real earnings management, which prior estimates reveal to be small as elicited by the optimal

[7] In Margiotta and Miller (2000), this cost is captured by the cost of inefficient risk transferred to the risk-averse manager; here, on the other hand, the cost is due to the fact that the manager must be given enough wealth when joining the relationship to provide effort.

contract - however, the main cost is via additional turnover of management which causes some non-trivial loss in firm value.

Table 9: Estimated effect of removing ability to manipulate earnings

$\frac{\Delta FV}{FV}$	$\frac{\Delta F0}{F_0}$	$\frac{\Delta w0}{w0}$	$\frac{\Delta ET}{ET}$
0.386%	0.305%	4.986%	11.842%
0.026%	0.016%	0.940%	0.915%

6 Conclusion

What are the economic consequences of serious misstatements? Several of major cases of corporate misstatements occurring over the last decades, with examples such as as Worldcom, Enron or Tyco, have caused concerns by regulators that accounting numbers are not of appropriate quality. Such concerns have triggered increases in the budget of the Securities and Exchange Commission from about $350 million to over $1.5 billion today, jointly with major overalls of regulatory surpersion with the Sarbanes-Oxley Act of 2004 and the PCAOB. At the same time, auditors and, by and large, the accounting academic profession view accounting and misstatements of accounting numbers as a second-order effect that is unlikely to matter relative to the economics of the firm.

We examine this question in a structural model, which makes no ex-ante assumption about the assumed severity of the economic consequences of misstatements, but allows to revisit the possible consequences of misstatements. In doing so, our objective is to evaluate the possible benefits of regulation in a model with both optimal contracts and real effects. We argue and find that accounting misstatements are, to be sure, not a first-order effect relative to the economic shocks but their likely effects on efficiency are sizeable and, in the aggregate, add up to billions of dollars in inefficiency. We hope that such an approach can contribute to, jointly with a large active body of research documenting the consequences of restatements, guide policy toward the desirability of enforcement both in the US and across other economics with active capital markets.

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